Data Quality Objectives for the Sampling of Terrestrial Plants and Laboratory Analysis of Tissues for Metals

Data Quality Objectives (DQOs) define the type, quality, quantity, purpose, and intended uses of data to be collected. As described in the United States (U.S.) Environmental Protection Agency's (EPA's) DQO guidance (EPA 2006), the DQO process typically follows a seven-step procedure, as follows.

1. State the Problem

Residents of the Confederated Tribes of the Colville Reservation (CCT) consume and otherwise utilize (e.g., for weaving) terrestrial, wetland and aquatic plants which may be contaminated with heavy metals. Other local residents and visitors to the Upper Columbia River (UCR) area may also utilize these resources. The UCR human health risk assessment (HHRA) work plan (EPA 2009) identified metal concentrations in upland and riparian plants as a data need. To assess risk posed by consuming or otherwise utilizing plants from the vicinity of the UCR, information on the concentration of metals in and on plants is needed, as well as information on the specific plants utilized by the CCT, how they are prepared for use, how they are used, and the frequency and amount collected and consumed.

Elevated metal concentrations have been measured in surface soils and beach sediment by various studies conducted in the Columbia River Valley corridor south of the U.S.-Canadian border, including:

- EPA Residential Soil Study (EPA 2015)
- Hart Crowser Upland Soil Study (Hart Crowser 2013), and
- Teck American Incorporated Upland Soil Study (TAI 2015).

Because plants may accumulate heavy metals from soil and sediment (e.g., Caranza-Alvarez et al. 2008, Intawongse and Dean 2006), EPA has determined that data required to estimate the exposure point concentrations (EPCs) for contaminants of interest (COIs) in and on plant tissue are needed for the UCR HHRA (SRC 2016). It is anticipated that decisions based upon exposure information for the CCT may also be protective of other area residents and visitors who utilize these resources, as the modern subsistence[1] exposure factors are likely to be greater than those for other non-tribal residents and visitors. Similarly, the study will be focused on the northernmost reach of the UCR, in the northeast portion of the Local Area (Figure 1), termed the "Study Area" in the remainder of these DQOs. Because COI concentrations are expected to be higher in the Study Area, decisions based on plant concentrations from this area should be protective of exposure to similar plants further from the border and the river.

2. Goals of the study

To inform exposure and risk calculations for the HHRA, plants will be collected from locations where there is potential for exposure to COIs by CCT residents and other people who collect plants. The concentrations of COIs in these plants will be compared to plants from reference areas (i.e., plants growing in areas that were not impacted by the SO_2 plume [USDA 1936]). Data from plants in reference

[1] "Modern subsistence" exposure factors represent the CCT; exposure factors for the Spokane Tribe of Indians, termed "traditional subsistence" exposure factors, will be taken from Harper et al. (2002).

areas will be used to interpret plant data collected from areas with contaminated soil, to provide information to people using plants.

The Tribal Consumption and Resource Use Survey (CCT Survey; Westat 2012) identified specific plants harvested from areas within the Local Area of the UCR basin. The Study Area is the northeastern portion of the Local Area and along the UCR because soil COI concentrations tend to be higher there (Hart Crowser 2013) and the CCT survey data indicate this area is a source for plants (Westat 2012). Because these users are the reasonable maximally exposed (RME) populations, if the HHRA is protective of the modern subsistence population, then it is likely protective of other users of these plant resources as well. While exposure to contaminants in and/or on plants may occur though other routes of exposure (e.g., handling or mouthing), ingestion of plants is likely to result in the highest exposure. Thus, if the concentration of COIs in and/or on plants are acceptable for direct ingestion, then exposure to contaminants in and/or on plants does not likely pose a risk through other uses of the plants.

In addition to exposure to COI in or on gathered plants, exposure may occur to soil and/or sediment during gathering. Ingestion of soil and/or sediment that may occur while harvesting plants will be evaluated in the HHRA using incidental soil-dust ingestion rates based on recent mass balance studies of indigenous people practicing wilderness lifestyle activities, including hunting and gathering (Doyle et al. 2012; Irvine et al. 2014).

Principal Human Health Risk Study Questions:

1. Does exposure to COIs from consuming wild plants in the UCR Study Area pose an unacceptable risk to human health via ingestion of plants?
2. Are the concentrations of COIs in wild plants sourced from the UCR Study Area greater than the concentrations of COIs in wild plants sourced from reference areas?
3. Does incidental ingestion of soil and/or sediment while gathering or harvesting plants in the UCR Study Area pose an unacceptable risk to human health?

3. Identify information inputs

Step 3 of the DQO process requires consideration of the types and potential sources of information that should be considered to provide estimates or resolve decisions, information needed to provide a basis for specifying performance or acceptance criteria, and information on the performance of appropriate sampling and analysis methods. Estimation of risk requires representative data for COIs in upland and riparian plants located within the Study Area that are consumed. Information inputs that are needed to conduct this analysis include knowledge about the frequency and amount that residents of the CCT harvest and consume upland and riparian plants, methods of preparing and using those plants, and COI concentrations in plants. Sampling and analytical methods must be appropriate to ensure that exposure point concentrations (EPCs) can be properly estimated for COIs and compared to toxicity benchmarks or other acceptance criteria.

The following plant species were identified in the CCT survey as consumed in the UCR Local Area (Westat 2012):

Upland/Terrestrial Plants	Lake and Wetland Plants	Beach Plants
Arrowleaf Balsamroot	Cedar	Red Willow (Red Osier Dogwood)
Cedar	Tule	
Chokecherry	Willow (Green , Grey, or Coyote)	
Hazelnut		
Huckleberry		
Moss/lichen		
Willow (Green , Grey, or Coyote)		
Sage (Big sage, white/silver sage)		
Soapberry		
Spring Beauty/Indian Potato		
Syringa (Mock Orange)		
Wild Blackberry		
Wild Mushroom – Morels, shaggy manes, and puffballs		
Wild Rose		
Wild Strawberry		

These plants were confirmed as being consumed by the CCT (Lodestone Environmental Consulting, 2016a). In the event that too few of these target plants can be found during field sampling to satisfy the collection mass required, the CCT identified other plants commonly found in the Study Area that are consumed by CCT members: serviceberry, elderberry, mullein, Oregon grape, and kinnikinnick (Lodestone 2016b).

Information that will inform the sampling design and analysis of plant tissue is described below and compiled in Tables 1, 2, and 3:

- The CCT survey (Westat 2012) will provide most of the information on the plant species consumed by the modern subsistence population and their sources (Figures 1 and 2).
- CCT input is needed to identify the location of plants of cultural importance, the amount of plants typically collected, methods used to process and prepare plants for consumption, the rate of consumption, the area over which the plants are typically harvested, and the timing of harvesting of different plant species.
- The study will consider use patterns that modify exposures (using exposure parameters for the RME [modern subsistence] population will ensure that the HHRA is protective of other users as well):
    - Who collects or harvests the plant (adults, children, or both), who prepares it for use, and who uses it
    - What parts of the plant are consumed (e.g., fruit, roots, leaves)
    - How the plants are prepared for consumption

    - When plants are typically harvested (season)
    - Typical frequency and amount of the plant collected (or area harvested) by an individual or family, and
    - Ingestion rate (g/day).
- COIs will be TAL metals[2] (except mercury) as specified by EPA in the UCR soil level of effort (LOE) document (EPA 2012a) and evaluated in the residential soil studies (EPA 2015, TAI 2016). Some of these COIs, such as calcium, sodium, and potassium, are essential nutrients and will not drive the HHRA, but are included here for consistency with these previous soil collection efforts (Goyer et al. 2004). Analytical methods for metals/metalloids in and on plant tissue are EPA Methods 6010B, 6020A, and 7742.
- Data for COI concentrations in soil and/or sediment from previous soil sampling efforts (Hart Crowser 2013, TAI 2015, EPA 2015) will be used to ensure that plant samples are collected from areas that represent contamination that is associated with the Site. In the event that plants are harvested from areas that were not previously sampled, soil and/or sediment samples will be collected from the 0-3" soil horizon. Analytical methods for metals/metalloids in soil and/or sediment are those specified in previous sampling events (EPA 2015, TAI 2016).

Plant tissue concentrations of COIs will be used by EPA as inputs to estimate chemical exposure due to the consumption of wild plants. The methods for estimating exposure to COI in and on plant tissue are described in the EPA HHRA work plan (EPA 2009). The benchmarks used for risk analysis (i.e., reference dose [RfD] and cancer slope factor [CSF]) provide information that will guide decisions used in the DQO process and may be used to assess risk from exposure to COIs once the plant tissue data are available. The risk benchmarks are specifically used to establish analytical concentration goals (ACGs; achievable analytical laboratory limits) to ensure that the analytical reporting limits are sufficiently low to provide data below the benchmarks and therefore the analytical results can be used by EPA in the HHRA.

Soil and/or sediment concentrations of COIs will be used by EPA as inputs to estimate chemical exposure due to incidental soil and/or sediment ingestion while collecting plants (both in the UCR Site Area and from reference locations). The methods for estimating exposure to COI in soil and/or sediment are described in the EPA HHRA work plan (EPA 2009). The benchmarks used for risk analysis (i.e., RfD and CSF) provide information that will guide decisions used in the DQO process and may be used to assess risk from exposure to COIs once the soil and/or sediment data are available. The risk benchmarks are specifically used to establish ACGs to ensure that the analytical reporting limits are sufficiently low to provide data below the benchmarks and therefore the analytical results can be used by EPA in the HHRA.

Risk-based concentrations for human health (RBCs), which aid in specifying performance or acceptance criteria (i.e., determination of risk or no risk), are provided in Tables 4 and 5. Because the exposure factors for utilization and consumption of wild plants by the CCT (modern subsistence) population are still in development, the more conservative exposure factors for the traditional subsistence (Spokane) population were used to derive RBCs and inform sample size calculations for this sampling effort. Using more conservative exposure factors ensures that an adequate sample is collected to inform risk assessment decisions for the modern subsistence population. Parameters and equations used to derive the RBCs are

[2] TAL metals include aluminum, antimony, arsenic, barium, beryllium, cadmium, calcium, chromium, cobalt, copper, iron, lead, magnesium, manganese, nickel, potassium, selenium, silver, sodium, thallium, vanadium, and zinc.

provided in Attachment A. For the baseline HHRA, exposure parameters that are appropriate for the modern subsistence population will be derived based on information from the CCT survey (SRC 2015, Westat 2012) and EPA guidance (e.g., USEPA 2011).

4. Define the boundaries (in space and time) of the study

This step of the DQO process specifies the population of interest for the study, the geographical boundaries of the Site, and any temporal considerations that may be required.

Population of Interest

The target population of interest for risk evaluation are the modern subsistence (CCT) population that consumes wild plants. As discussed in Step 3 above, because the final exposure factors for the CCT have not been determined, exposure factors for the traditional subsistence were used to derive RBCs and inform sample size calculations for this sampling effort .The CCT Survey (SRC 2015, Westat 2012) provides a list of plants that are ingested by the CCT and their approximate location. The list of plants species of primary interest, developed with input from the CCT, is in Tables 1, 2 and 3. The target plant population for sampling consists of specific plant species-"plant part" combinations (e.g., black camas bulbs and huckleberry fruits).

Geographic Boundary

The UCR Site area consists of the areal extent of hazardous substances contamination within the U.S. in or adjacent to the UCR, including the Franklin D. Roosevelt Lake ("Lake Roosevelt"), from the border between the U.S. and Canada downstream to the Grand Coulee Dam and all suitable areas in proximity to such contamination necessary for implementation of the Remedial Investigation/Feasibility Study (RI/FS). Available soils data indicate contamination is highest along the UCR and tends to decrease with distance south from the U.S.-Canada border (Shannon & Wilson, Inc. 2011; Hart Crowser 2013). The Study Area for the plant tissue DQOs is the northeast portion of this area. The literature indicates the relationship between metals concentration in soil and plants is affected by many potential factors; some studies have identified a linear or non-linear relationship for some metals and some plants (e.g., BJC 1998) while others have not found a substantial relationship (BJC 1998; McBride et al. 2014). To the extent possible given the locations of the plant species of interest (e.g., CCT zones in the Westat 2012 survey), plant samples will be collected from areas where exposure is expected to be greatest from contamination in soil/sediment. The areas for sampling will include Tribal allotments and publicly accessible lands along the UCR corridor, primarily north of China Bend. The areas of initial concern, based on elevated levels of metals found in soil, are contained within CCT survey zones 481, 482, 483, and 490, and beach/floodplain areas of R1, R2, and R3 (CCT zones in the Westat 2012 survey). In addition, plants will be collected from reference locations. These will be plants growing in areas that were not impacted by the SO_2 plume. Where appropriate, sampling will be limited to specific target plants that provide roots, vegetative matter, and/or fruit that are consumed (see tables 1, 2, and 3 for more information).

Temporal Boundary

Depending on the target plant species that are identified for sampling, there may be specific temporal boundaries for collecting plant samples. The appropriate time for collecting plant samples may depend on

the plant part consumed (e.g., roots versus fruit) as well as the growing season for the plant species. This information is compiled in Tables 1, 2 and 3.

Target Population:	specific plant species-"plant part" combinations (e.g., black camas bulbs and huckleberries[3]).
Sampling Unit:	individual species-"plant part" combinations (e.g., black camas bulbs). Some plant materials may require compositing to obtain a sufficient mass of dry material for analysis; e.g., compositing may consist of berries from a single plant or from separate plants located within a small area that represent an area where an individual or family would collect plant material.
Decision Unit:	Initially, the decision unit corresponds to the location of the sampling units. Depending on the variability of the plant tissue data, existence of trends, etc., it may be possible to generalize the results.

5. Develop the analytic approach

Step 5 of the DQO process provides the analytical approach for evaluating the plant tissue data and incidental soil and/or sediment exposure related to plant harvesting in the HHRA. Concentrations of COIs in and on plant tissue will be used to estimate exposure of humans and potential associated health risks. Concentrations of COIs in soil and/or sediment from the UCR Site Area will be used to estimate exposure of humans via incidental ingestion and potential associated health risks. Concentrations of COIs in the soil and/or sediment from reference areas will be compared to the soil and/or sediment results from the UCR Site Area to verify that the reference plants were collected from areas that are not associated with site impacts. The analytical procedures for this study are standard EPA-approved analytical protocols with detection limits that are generally sufficiently low to provide detects that are below RBCs.

Plant samples: Estimates of COI concentration in plants will be specific to plant species-"plant part" combinations. Specific sampling methods will be described in the field sampling plan (FSP). Timing of collection of plant samples will be based on when the targeted plant part (species specific) is available. Plant samples will be collected using dedicated (or decontaminated) pruning shears and/or knives. Whole plants or selected parts (e.g., roots, leaves, fruits) will be collected, weighed as soon as possible after cutting, and placed in a re-sealable plastic bag and kept cool (4^{o} centigrade [C]); samples will not be frozen. Unless inconsistent with CCT use, plant parts will be analyzed as they are prepared. If plant parts are typically washed or quickly washed prior to consumption, that is how they will be prepared prior to analysis. Given that individual plant species and plant parts may be consumed or prepared differently, each plant species and plant part will be prepared for analysis as is typically done by the CCT (see Tables 1, 2 and 3).

If plant parts will not be analyzed upon sample receipt, plant tissue should be dried at 75^{o} C for 24 to 48 hours, cooled, and reweighed (dry weight). Tissue should be weighed at 4 to 8 hour intervals, replacing the material in the oven between weighings, until normal water weight is lost (i.e., to a constant weight). Care must be taken not to cook or char the plant material. Less succulent tissues may be left to dry at

[3]Black camas bulbs and huckleberries were identified in the UCR surveys (Westat 2012) as being the most frequently used wild plants.

room temperature in open paper bags before completing the process in the oven. Samples should not be allowed to decay before drying.

COIs will be measured using microwave digestion (SW-846 Test Method 3051) and analyzed by EPA Methods 6010B/C, 6020A, and 7471B/1631E. The moisture content of plant tissue, specific to plant parts (e.g., roots, fruits), will be determined. Laboratory method reporting limits (MRLs) and method detection limits (MDLs) are given in Table 4.

Commented [JR1]: Need these from the lab

Soil and/or sediment samples: Estimates of COI concentrations in soil and/or sediment from the area where plants are harvested (in both the UCR Site Area and reference locations). Specific sampling methods will be described in the Field Sampling Plan. Analytical methods for metals/metalloids in soil and/or sediment are those specified in previous sampling events (EPA 2015, TAI 2016).

6. Specify performance or acceptance criteria

The DQO process is designed to ensure that the type, quantity, and quality of environmental data used in decision making will be appropriate for its intended use, resulting in decisions that are technically and scientifically sound and defensible. ACGs are the desired analytical quantitation limits for the study. If possible, ACGs will be sufficiently low to provide reporting limits below the RBCs, such that non-detected data can be "screened out" as less than RBCs. RBCs were calculated based on the maximally exposed receptor population from the HHRA work plan (EPA 2009). For sample size calculations, the traditional subsistence exposure scenario inputs are used except for soil ingestion rates which are based on Region 10 reanalysis of Doyle studies (Stifelman 2016). This ensures that sufficient sample is collected to inform the risk assessment. The ACGs for each COI are listed in Tables 4 and 5. Finally, laboratory duplicates, matrix spike/matrix spike duplicates (MS/MSD), and standard reference materials (SRM) samples will be used to evaluate analytical variability and method performance. Analytical data meeting the ACGs and found within analytical method performance criteria will be considered adequate to answer the principal human health risk study questions defined in Step 2 above.

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Baseline and alternative conditions (null and alternative hypothesis)

Principal study question #1:

Null hypothesis (H_0): the mean concentration of [metal] in [plant] [part] ≥ [RBC]
Alternative hypothesis (H_1): the mean concentration of [metal] in [plant] [part] < [RBC]

Principal study question #2:

Null hypothesis (H_0): the mean concentration of [metal] in [plant] [part] from UCR study area > the mean concentration of [metal] in [plant][part] from the reference area
Alternative hypothesis (H_1): the mean concentration of [metal] in [plant] [part] from UCR study area ≤ the mean concentration of [metal] in [plant][part] from the reference area

note: The test for principal study question #2 is only implemented when the null hypothesis for principal study question #1 is not rejected (i.e., when the null hypothesis of unacceptable risk is not rejected).

Principal study question #3:

Null hypothesis (H_0): the mean concentration of [metal] in soil and/or sediment ≥ [RBC]
Alternative hypothesis (H_1): the mean concentration of [metal] in soil and/or sediment < [RBC]

Steps 6 and 7 to be completed when MDLs and MRLs are received from the lab.

Table 1. Upland Plants to be Collected

Plant	Cited Location	Plant Part(s) Used	Time(s) of Year Collected	Typical Amount Collected	Process to Prepare Plant for Use (Wash, peel, etc.)	How Plant is Used (Exposure Route)	How Much is Consumed (g/day)	Notes	Reference
Alder	Northern half of Site								
Arrowleaf Balsamroot	482, 483, 490, R1, R2, R3	Shoots, seeds, roots	Early spring (first week of April) for shoots; late spring/early summer (last week of June) for seeds and roots						
Cedar	482, 483, 490, R1, R2, R3	Bark, root, outer root bark, whole boughs/ needles/ stems, berries	Late spring/early summer (last week of June); berries collected in summer (last week of August)		Strip bark from tree, gather wood for construction, dig roots	Bark consumed in tea, used for dying/coloring material and weaving, used in construction; wood used in construction material; roots used for weaving and in construction		In ReUp, oral exposure reported for 13% using bark for construction, 18% using bark for weaving, and 12% using bark for medicinal/spiritual practices in tea. Oral exposure reported for 31% using wood for construction. Oral exposure reported for 19% using roots for weaving, and 66% using roots for construction	Westat 2012; http://wildfoodsandmedicines.com/cedar/; http://treekb.com/cedar-tree-root-system/
Chokecherry	482, 483, 490, R1, R2, R3	Fruit	Summer (last week of August)						
Hazelnut	503 and 572	Nut	Summer (last week of June)						

Plant	Cited Location	Plant Part(s) Used	Time(s) of Year Collected	Typical Amount Collected	Process to Prepare Plant for Use (Wash, peel, etc.)	How Plant is Used (Exposure Route)	How Much is Consumed (g/day)	Notes	Reference
Huckleberry (Black, blue, or red)	503 and 572	Fruit	Summer (early August)		Berries picked and sometimes crushed	Ingested		In ReUp, 75% of CCT residents ≥2 years old reported eating them.	Westat 2012; http://wdfw.wa.gov/fishing/vacation/colville.html; http://plants.usda.gov/plantguide/pdf/cs_vame.pdf
Indian Hemp (dogbane)	Northern half of Site								
Moss/lichen	Northern half of Site								
Green, Grey, or Coyote Willow	482, 483, 490, R1, R2, R3	Leaves, stem, bark, inner cambium	Early spring (first week of April)		Grind or prepare bark for medicinal use or tea; strip bark from tree	Bark consumed in tea or medicinal uses, used for weaving; wood used in construction.		In ReUp, oral exposure reported for 22% using bark for weaving; 37% using bark for medicinal/spiritual practice ingested bark; 34% used bark in tea. Oral exposure reported for 35% using wood for construction.	Westat 2012; USDA 2003
Sage (big sage, white/silver sage)	482, 483, 490, R1, R2, R3		Early spring (first week of April)		Gather after new leaves appear				
Soapberry	482, 483, 490, R1, R2, R3	Fruit	Summer (last week of August)						
Spring Beauty/Indian potato	482, 483, 490, R1, R2, R3	Root	Early spring (first week of April)						
Syringa (Mock Orange)	482, 483, 490, R1, R2, R3	Branches	Early spring (first week of April)		Peeled				

Plant	Cited Location	Plant Part(s) Used	Time(s) of Year Collected	Typical Amount Collected	Process to Prepare Plant for Use (Wash, peel, etc.)	How Plant is Used (Exposure Route)	How Much is Consumed (g/day)	Notes	Reference
Wild Blackberry	482, 483, 490, R1, R2, R3	Fruit	Summer (last week of August)						
Wild Rose	482, 483, 490, R1, R2, R3	Rose hips, stems, roots	Summer (last week of August)						
Wild Strawberry	503 and 572	Fruit	Late spring/early summer (last week of June)						

Table 2. Lake and Wetland Plants to be Collected

Plant	Cited Location	Plant Part(s) Used	Time(s) of Year Collected	Typical Amount Collected	Process to Prepare Plant for Use (Wash, peel, etc.)	How Plant is Used (Exposure Route)	How Much is Consumed (g/day)	Notes	Reference
Cedar	481 and 482	Bark, root, outer root bark, whole boughs/needles/stems, berries	Late spring/early summer (last week of June); berries collected in summer (last week of August)						
Tule	481 and 482	Stalk	Summer (last week of August)						
Wild mushroom (morels, shaggy manes, puffballs)	481 and 482		Early spring (first week of April)						

Table 3. Beach Plants to be Collected

Plant	Cited Location	Plant Part(s) Used	Time(s) of Year Collected	Typical Amount Collected	Process to Prepare Plant for Use (Wash, peel, etc.)	How Plant is Used (Exposure Route)	How Much is Consumed (g/day)	Notes	Reference
Red Willow	R4a	Leaves, stem, bark, inner cambium	Early spring (first week of April)						

Table 4. Target Analyte List, Method Detection and Reporting Limits, Analytical Concentration Goals, and Human Health Risk-Based Concentrations for Plant Tissue

Analyte	RBC[a]	MRL	MDL	ACG
Conventional Parameters				
Total Mass	NA			
Percent Moisture	NA			
Metals (mg/kg dry weight)				
Aluminum	56			
Antimony	0.02			
Arsenic	0.0008			
Barium	11			
Beryllium	0.11			
Cadmium	0.06			
Calcium	NA			
Chromium III	83			
Cobalt	0.02			
Copper	2.2			
Iron	39			
Lead	0.08[b]			
Magnesium	NA			
Manganese	7.8			
Nickel	1.1			
Potassium	NA			
Selenium	0.28			
Silver	0.28			
Sodium	NA			
Thallium	0.0006			
Vanadium	0.28			
Zinc	17			

[a]RBCs were calculated for adults and children who ingest plants. When determining the final chemical-specific RBC, the lower of the child non-cancer RBC and the time-weighted average (TWA) RBC for carcinogenic chemicals was selected. See Attachment A for additional detail.

[b]The RBC for lead was calculated as the lead ingestion rate (5 µg/day) divided by the plant ingestion rate.

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Commented [JR4]: Will be determined once MRLs and MDLs have been received from the lab.

Table 5. Target Analyte List, Method Detection and Reporting Limits, Analytical Concentration Goals, and Human Health Risk-Based Concentrations for Soil and Sediment

Analyte	RBC[a]	MRL	MDL	ACG
Conventional Parameters				
Total Mass	NA			
Percent Moisture	NA			
Metals (mg/kg dry weight)				
Aluminum	5,000			
Antimony	2			
Arsenic	0.29			
Barium	1,000			
Beryllium	10			
Cadmium	5			
Calcium	NA			
Chromium III	7,500			
Cobalt	1.5			
Copper	200			
Iron	3,500			
Lead	143[b]			
Magnesium	NA			
Manganese	120			
Nickel	100			
Potassium	NA			
Selenium	25			
Silver	25			
Sodium	NA			
Thallium	0.05			
Vanadium	25			
Zinc	1,500			

[a]RBCs were calculated for adults and children who incidentally ingest soil or sediment when harvesting or using plants. When determining the final chemical-specific RBC, the lower of the child non-cancer RBC and the time-weighted average (TWA) RBC for carcinogenic chemicals was selected. See Attachment A for additional detail.

[b]The RBC for lead is the RBC for children, and was calculated using the Integrated Exposure Uptake Biokinetic Model for Lead with default inputs except for a soil-dust ingestion rate of 300 mg/day.

Commented [JR5]: Need from the lab

Commented [JR6]: Will be determined once MRLs and MDLs have been received from the lab.

References

Bechtel Jacobs Company LLC (BJC). 1998. Empirical models for the uptake of inorganic chemicals from soil by plants. Prepared for the U.S. Department of Energy, Office of Environmental Management. East Tennessee Technology Park. BJC/OR-133. September.

Carranza-Álvarez, C., A.J. Alonso-Castro, M.C. Alfara-De La Torre, and R.F. García-De La Cruz. 2008. Accumulation and distribution of heavy metals in *Scirpus americanus* and *Typha latifolia* from an artificial lagoon in San Luis Potosí, México. Water Air Soil Pollut 188: 297-309.

Doyle, J. R., J. M. Blais, R. D. Holmes and P. A. White. 2012. "A soil ingestion pilot study of a population following a traditional lifestyle typical of rural or wilderness areas." The Science of the total environment 424: 110-120.

EPA. 2005. Final Midnite Mine human health risk assessment report. U.S. Environmental Protection Agency, Region 10, Seattle, WA. September.

EPA. 2006. Guidance of systematic planning using the data quality objectives process (EPA QA/G-4). United States Environmental Protection Agency, Washington, D.C. EPA/240/B-06/001.

EPA. 2009. Human health risk assessment work plan for the Upper Columbia River site remedial investigation and feasibility study. Prepared for, and with oversight by, United States Environmental Protection Agency, Region 10. Prepared by Syracuse Research Corporation. March.

EPA. 2011. Exposure factors handbook: 2011 edition. U.S. Environmental Protection Agency, Office of Research and Development, Washington, DC. EPA/600/R-090/052F. September.

EPA. 2012a. U.S. EPA Technical Team Level of Effort (LOE) for Sampling and Analysis of Soil in the Upper Columbia River Basin (Soil LOE). Environmental Protection Agency, Region 10: Seattle, WA. 9 pp.

EPA 2012b. Recommendations for default value for relative bioavailability of arsenic in soil. December 2012. OSWER 9200.1-113.

EPA. 2014. Human health evaluation manual, supplemental guidance: update of standard default exposure factors. OSWER Directive 9200.1-120. Office of Solid Waste and Emergency Response.

EPA. 2015. Upper Columbia River Residential Soil Study Field Sampling and Data Summary Report. Draft Final. October.

Goyer, R. A., M. S. Golub, H. Choudhury, M. Hughes, E. Kenyon and M. L. Stifelman. 2004. Papers Addressing Scientific Issues in the Risk Assessment of Metals. Issue Paper on the Human Health Effects of Metals. Washington D.C., U.S. EPA Risk Assessment Forum: 41. http://cfpub.epa.gov/ncea/raf/recordisplay.cfm?deid=59052

Harper, B.L., B. Flett, S. Harris, C. Abeyta, and F. Kirschner. 2002. The Spokane Tribe's multipathway subsistence exposure scenario and screening level RME. Risk Analysis 22: 513-526.

Hart Crowser. 2013. Upper Columbia River Upland Soil Sampling Study, Stevens County, Washington. Seattle, WA, Prepared by Hart Crowser for the Washington State Department of Ecology: p. 22 plus figures, tables, and appendices. https://fortress.wa.gov/ecy/gsp/CleanupSiteDocuments.aspx?csid=12125

Intawongse, M. and J.R. Dean. 2006. Uptake of heavy metals by vegetable plants grown on contaminated soil and their bioavailability in the human gastrointestinal tract. Food Additives and Contaminants 23(1): 36-48.

Irvine, G., J. R. Doyle, P. A. White and J. M. Blais. 2014. "Soil ingestion rate determination in a rural population of Alberta, Canada practicing a wilderness lifestyle." Science of The Total Environment 470–471(0): 138-146.

Lodestone Environmental Consulting. 2016a. Cultural plant sampling reconnaissance. Memorandum prepared for Confederated Tribes of the Colville Reservation. October 31.

Lodestone Environmental Consulting. 2016b. Cultural plant sampling reconnaissance results and information for EPA. Memorandum prepared for Confederated Tribes of the Colville Reservation. November 7.

McBride, M.B., Shayler, H.A., Spliethoff, H.M., Mitchell, R.G., Marquez-Bravo, L.G., Ferenz, G.S., Russell-Anelli, J.M., Casey, L. and S. Bachman. 2014. Concentrations of Lead, Cadmium and Barium in Urban Garden-Grown Vegetables: the Impact of Soil Variables. Environ Pollut. 194:254-261.

Ruby, M.V. and Y.W. Lowney (2012). Selective soil particle adherence to hands: implications for understanding oral exposure to soil contaminants. Environ Sci Technol 46(23): 12759-12771. http://www.ncbi.nlm.nih.gov/pubmed/23148503.

Ramboll Environ. 2016. Upper Columbia River Final 2016 Residential Soil Study Quality Assurance Project Plan, Addendum No. 1 to the 2014 Residential Soil Study Quality Assurance Project Plan (SRC Inc. 2014). Prepared for Teck American Incorporated. July.

Shannon & Wilson, Inc. 2011. Soil Remediation, Land Port of Entry Facility, Boundary, Washington. Seattle, WA 98103. Website: http://www.shannonwilson.com/.

SRC. 2015. Data Analysis Report for the Tribal Consumption and Resource Use Survey for the Upper Columbia River Site Human Health Risk Assessment and Remedial Investigation/Feasibility Study. Prepared for: U.S. Environmental Protection Agency, Region 10, Seattle, Washington. February 5.

SRC. 2016. Memorandum to Dustan Bott, Laura Buelow, Marc Stifelman (EPA Region 10), Subject: Revised Upper Columbia River (UC) Plant Tissue Data Adequacy Analysis. January 14.

Stifelman, M. 2016. Proposal for Region 10 Adult Tribal Subsistence Soil Ingestion Rate (based on reanalysis of Doyle et al. 2012 and Irvine et al. 2014).

Teck American Incorporated (TAI). 2015. Draft Soil Study Data Summary and Data Gap Report. April.

TAI. 2016. Draft Final 2016 Residential Soil Study Quality Assurance Project Plan. Addendum No. 1 to the 2014 Residential Soil Study Quality Assurance Project Plan (SRC Inc. 2014). Prepared for Teck American Incorporated. Prepared by Ramboll Environ. June.

U.S. Department of Agriculture (USDA). 1936. "Maps of the areas of injury to the forests in northern Stevens County, Washington, due to the effects of sulphur dioxide in the air," Prepared by George C. Hedgecock, Senior Pathologist, Division of Plant Industry, U.S. Department of Agriculture.

USDA. 2003. Pacific Willow (*Salix lucida* Muhl. ssp.) Plant Guide. U.S. Department of Agriculture Natural Resources Conservation Service. https://plants.usda.gov/plantguide/pdf/cs_salul.pdf

Westat. 2012. Upper Columbia River Site Remedial Investigation and Feasibility Study Tribal Consumption and Resource Use Survey. Final Report. Submitted to U.S. Environmental Protection Agency Region 10. June 22.

Attachment A

Risk-based concentrations (RBCs) are based on the maximally exposed receptor population (traditional subsistence scenario) from the HHRA work plan (EPA 2009). RBCs were back-calculated based on a target hazard quotient (THQ) of 0.1 for non-cancer and a target cancer risk (TR) of 1E-06.

RBCs were calculated separately for ingestion of plants and for incidental soil and/or sediment ingestion. These are described below.

Human Health RBCs for plant ingestion:

RBCs were calculated for both adults and children who consume wild plants. When determining the final chemical-specific RBC, the lower of the child non-cancer RBC and the time-weighted average (TWA) RBC for carcinogenic chemicals was selected. The equation used to calculate the RBCs for non-cancer hazard and cancer risk from consumption and other uses of wild plants are:

$$RBC_{non-cancer} = \frac{THQ \times AT \times BW \times RfD}{EF \times ED \times FR \times IR \times CF}$$

and

$$RBC_{cancer} = \frac{TR \times AT \times BW}{EF \times ED \times CSF \times IR \times CF \times FR}$$

where:

THQ	=	total hazard quotient (0.1)
AT	=	averaging time (23,360 days/year for adults, non-cancer; 1,460 days/year for children, non-cancer; 25,550 for adults and children, cancer; U.S. EPA 2011)
ED	=	exposure duration (64 years for adults; 4 years for children[4]; Harper et al. 2002)
BW	=	body weight (80 kg for adults; 15 kg for children; U.S. EPA 2014)
EF	=	exposure frequency (365 days/year; Harper et al. 2002 and professional judgement)
RfD	=	oral reference dose (see table)
IR	=	plant ingestion rate for terrestrial and aquatic plants gathered from the UCR site (800 g/day for adults based on Harper et al. 2002; 360 g/day for children based on U.S. EPA 2005)[5]
CF	=	conversion factor (1E-3 kg/g)
TR	=	total cancer risk (1E-6)

[4] Assumes children breastfeed for the first 2 years of life

[5] Adult wild plant consumption rate assumed to be one-half of the vegetable ingestion subsistence value of 1,600 g/day taken from Table I (one-half assumed from crops, one-half assumed from gathering activities such as being investigated here). Child wild plant consumption rate assumed to be one-half of the plant ingestion value of 720 g/day in Table 3-9 of the Midnite Mine HHRA (one-half assumed from crops, one-half assumed from gathering activities).

FR = fraction of meals from UCR (1; professional judgement), and
CSF = oral cancer slope factor (see table).

RBCs ingestion of plant tissue were converted to dry weight values assuming a plant moisture content of 85 percent based on the average moisture content of produce in Table 9-37 of the Exposure Factors Handbook (EPA 2011).

Human Health RBCs for incidental soil and/or sediment ingestion:

RBCs were calculated for both adults and children who incidentally ingest soil and/or sediment while gathering and preparing wild plants for consumption and other uses. Arsenic relative bioavailability in soil was assumed to be 60% (EPA 2012b). When determining the final chemical-specific RBC, the lower of the child non-cancer RBC and the TWA RBC for carcinogenic chemicals was selected. The equation used to calculate the RBCs for non-cancer hazard and cancer risk from incidental ingestion of soil and/or sediment are:

$$RBC_{non-cancer} = \frac{THQ \times AT \times BW \times RfD}{EF \times ED \times IR \times CF}$$

and

$$RBC_{cancer} = \frac{TR \times AT \times BW}{EF \times ED \times CSF \times IR \times CF}$$

where:

THQ = total hazard quotient (0.1)
AT = averaging time (23,360 days/year for adults, non-cancer; 1,460 days/year for children, non-cancer; 25,550 for adults and children, cancer; U.S. EPA 2011)
ED = exposure duration (64 years for adults; 4 years for children[6]; Harper et al. 2002)
BW = body weight (80 kg for adults; 15 kg for children; U.S. EPA 2014)
EF = exposure frequency (365 days/year; Harper et al. 2002 and professional judgement)
RfD = oral reference dose (see table)
IR = incidental ingestion rate of soil and/or sediment (239 mg/day for adults [Stifelman 2016] and 300 mg/day for children[7] [Harper et al. 2002])
CF = conversion factor (1E-6 kg/mg)
TR = total cancer risk (1E-6), and
CSF = oral cancer slope factor (see table).

[6] Assumes children breastfeed for the first 2 years of life.
[7] Soil intake rate in Harper et al. (2002) is reported as 400 mg/day (100 mg/day from indoor sources plus 300 mg/day from outdoor sources). Assumed the following: that UCR site exposures were restricted to outdoor scenarios only; that reported soil intake rates applied to sediment exposures as well; and that intake rates for children equaled adults. This is supported by Section 3.7 in Harper et al. 2002, which identifies soil intake rates for children and adults as being equal.

Oral RfDs and CSFs for the COIs were obtained from the U.S. EPA Regional Screening Level (RSL) calculator (www.epa.gov/risk/regional-screening-levels-rsls-equations-may-2016). These values are as follows:

Analyte	**Oral RfD (mg/kg-day)**	**Oral CSF (mg/kg-day)$^{-1}$**
Aluminum	1	NA[a]
Antimony	0.0004	NA
Arsenic	0.0003	1.5
Barium	0.2	NA
Beryllium	0.002	NA
Cadmium	0.001	NA
Calcium	NA	NA
Chromium III	1.5	NA
Cobalt	0.0003	NA
Copper	0.04	NA
Iron	0.7	NA
Lead	NA	NA
Magnesium	NA	NA
Manganese – plants (diet)	0.14	NA
Manganese – soil/sediment (non-diet)[b]	0.024	NA
Nickel	0.02	NA
Potassium	NA	NA
Selenium	0.005	NA
Silver	0.005	NA
Sodium	NA	NA
Thallium	0.00001	NA
Vanadium	0.005	NA
Zinc	0.3	NA

[a]NA = not available.

[b]As stated in the RSL user's guide (https://www.epa.gov/risk/regional-screening-levels-rsls-users-guide-may-2016), IRIS recommends substracting the dietary contribution of manganese from the normal U.S. diet when evaluating non-food exposures (e.g., soil/sediment ingestion), and further modifying the RfD by a factor of 3 due to a number of uncertainties discussed in IRIS, resulting in a non-diet oral RfD of 0.024 mg/kg-day.